

ORIGINAL ARTICLE

A comparison of physiological and anthropometric characteristics among playing positions in junior rugby league players

T J Gabbett

Br J Sports Med 2005;39:675–680. doi: 10.1136/bjism.2005.018275

Objectives: To compare the physiological and anthropometric characteristics of specific playing positions and positional playing groups in junior rugby league players.

Methods: Two hundred and forty junior rugby league players underwent measurements of standard anthropometry (body mass, height, sum of four skinfolds), muscular power (vertical jump), speed (10, 20, and 40 m sprint), agility (L run), and estimated maximal aerobic power (multi-stage fitness test) during the competitive phase of the season, after players had obtained a degree of match fitness.

Results: Props were significantly ($p < 0.05$) taller, heavier, and had greater skinfold thickness than all other positions. The halfback and centre positions were faster than props over 40 m. Halfbacks had significantly ($p < 0.05$) greater estimated maximal aerobic power than props. When data were analysed according to positional similarities, it was found that the props positional group had lower 20 and 40 m speed, agility, and estimated maximal aerobic power than the hookers and halves and outside backs positional groups. Differences in the physiological and anthropometric characteristics of other individual playing positions and positional playing groups were uncommon.

Conclusions: The results of this study demonstrate that few physiological and anthropometric differences exist among individual playing positions in junior rugby league players, although props are taller, heavier, have greater skinfold thickness, lower 20 and 40 m speed, agility, and estimated maximal aerobic power than other positional playing groups. These findings provide normative data and realistic performance standards for junior rugby league players competing in specific individual positions and positional playing groups.

Correspondence to:
Dr Tim J Gabbett,
Queensland Academy of
Sport, Brisbane, Australia;
tim.gabbett@qld.gov.au

Accepted
16 February 2005

Rugby league is an international collision sport played by sub-elite and elite competitors. The game is intermittent in nature, requiring players to compete in a challenging contest comprising intense bouts of sprinting and tackling separated by short bouts of lower intensity activity (recovery).¹ As a result of the physical demands of the game, the physiological qualities of players are highly developed with players requiring high levels of aerobic fitness, speed, muscular strength and power, and agility.^{1–3}

Rugby league team positions can be broadly classified as either forwards (all players involved in the scrum) or backs (all players not involved in the scrum). Team positions can also be classified according to the specific individual position played (prop, hooker, second row, lock, halfback, five-eighth, centre, wing, and fullback), or according to four subgroups reflecting positional similarities (props, hookers and halves, backrowers, and outside backs).^{4–5} Time-motion studies have shown that rugby league players perform different match play activities during competition depending on playing position,⁶ with forwards involved in significantly more physical collisions and tackles than backs.⁷ It is also recognised that the ratio of high intensity activity to low intensity activity is higher for forwards compared to backs (1:7 to 1:10 v 1:12 to 1:28), with forwards covering greater distance during a match (9929 v 8458 m).⁶ These findings demonstrate that in rugby league a wide range of skills and physiological demands exists for different playing positions.

Previous studies of the physiological and anthropometric characteristics of senior rugby league players have shown significant differences amongst playing positions for height,⁵ body mass,^{4,5} skinfold thickness,^{4,5} estimated maximal aerobic power,⁵ speed,^{4,5,8} repeated sprint ability,⁸ and

muscular strength.^{4,5} However, while studies have investigated the physiological and anthropometric characteristics of senior rugby league players,^{4,5,9–11} physical performance profiles of junior rugby league players are limited.^{12,13} In a study of junior (under 13–16) rugby league players, Gabbett¹² reported significant differences in selected physical characteristics between forwards and backs, with backs significantly lighter and demonstrating greater aerobic fitness than forwards. In a subsequent study, Gabbett and Herzig¹³ reported differences in the physiological and anthropometric characteristics of junior rugby league forwards and backs, with backs significantly lighter and demonstrating greater lower body muscular power, speed, and estimated maximal aerobic power than forwards. While these studies have provided important information on the fitness of junior rugby league forwards and backs, to date, no data exist on the physiological and anthropometric characteristics of specific individual playing positions and positional playing groups in junior rugby league players. With this in mind, the purpose of the present study was to compare the physiological and anthropometric characteristics of specific playing positions and positional playing groups in junior rugby league players.

METHODS

Subjects

Two hundred and forty junior rugby league players participated in this study. Players were aged 16–18 years and were competing in the Gold Coast junior rugby league competition (Queensland Rugby League, Australia). Although the players competed with the goal of reaching and winning the grand final, the junior rugby league competition could be described

as a sub-elite competition. All subjects received a clear explanation of the study, including the risks and benefits of participation, and written parental or guardian consent was obtained before players were permitted to participate. The Institutional Review Board for Human Investigation approved all experimental procedures.

Procedure

The rugby league season lasted from December through to September. The pre-season training period lasted from December through to February with matches played from February through to September. All fitness testing was conducted during the competitive phase of the season (May), after players had obtained a degree of match fitness. Fitness testing was conducted on the same day of the week (Tuesday), at least 3 days after participating in a match. The coaches of the various teams stated that they were prepared to devote one training session (approximately 90 min) to the field testing. Although consideration was given to the specificity of the field test, the selection of tests included in the field testing battery was influenced by this time constraint.

Fitness testing battery

Standard anthropometry (height, body mass, and sum of four skinfolds)¹⁴ measurements were taken and muscular power (vertical jump),¹² speed (10, 20, and 40 m sprint),⁵ agility (L run),¹⁵ and estimated maximal aerobic power (multi-stage fitness test)¹⁶ were measured. Subjects were instructed to refrain from strenuous exercise for at least 48 h prior to the fitness testing session and consume their normal pre-training diet prior to the testing session. At the beginning of the field testing session, anthropometric measurements were taken for each subject. After anthropometric measurements were taken, subjects underwent a standardised warm up (progressing from low to higher intensity activities) and stretching routine. Ad libitum fluid intake was permitted after anthropometric measurements were taken.

Subjects were randomly allocated into three groups consisting of approximately equal numbers of players. Subjects in group 1 underwent measurements of muscular power (vertical jump), while speed (10, 20, and 40 m sprint) was recorded for group 2. Group 3 performed the agility test (L run). Subjects performed two trials for the speed, muscular power, and agility tests,¹² with a recovery period of 2–3 min between trials. Players were encouraged to perform low intensity activities and stretches between trials to minimise reductions in performance. Subjects completed all tests in football boots. Upon completion of the respective tests, each group rotated until all tests had been performed. The field testing session was concluded with subjects performing the multi-stage fitness test (estimated maximal aerobic power). To standardise conditions between teams, testing was conducted on the same ground at the same time of day. The same investigator conducted the same test for each individual team.

Anthropometry

Excess body fat has been shown to negatively influence performance (for example, power to body mass ratio, thermoregulation, and aerobic capacity).⁴ As an estimate of adiposity, skinfold thickness was measured at four sites using a Harpenden skinfold calliper. The same experienced tester conducted all skinfold measurements, and was accredited by the Australian Laboratory Standards Assistance Scheme and the International Society for the Advancement of Kinanthropometry. The four sites selected were biceps, triceps, subscapular, and suprailiac. The exact positioning of each skinfold measurement was in accordance with

procedures described by Norton *et al.*¹⁴ Height was measured using a stadiometer and body mass was measured using calibrated digital scales (A & D, Tokyo, Japan). The intraclass correlation coefficient for test-retest reliability and typical error of measurement for height, body mass, and sum of four skinfold measurements were 0.99, 0.99, and 0.99, and 0.2%, 0.8%, and 3.0%, respectively.

Vertical jump

The ability to generate high levels of muscular power is an important attribute of rugby league players. Players are required to have high levels of muscular power in order to effectively perform the tackling, lifting, pushing, and pulling tasks that occur during a match.⁴ In addition, high levels of muscular power are required to provide fast play-the-ball speed and leg drive in tackles.¹ Lower body muscular power was estimated by means of the vertical jump test¹² using a Yardstick vertical jump device (Swift Performance Equipment, New South Wales, Australia). Players were requested to stand with feet flat on the ground, extend their arm and hand, and mark the standing reach height. After assuming a crouch position, each subject was instructed to spring upward and touch the Yardstick device at the highest possible point. No specific instructions were given about the depth or speed of the countermovement. Vertical jump height was calculated as the distance from the highest point reached during standing and the highest point reached during the vertical jump. Vertical jump height was measured to the nearest 1 cm with the highest value obtained from two trials used as the vertical jump score. The intraclass correlation coefficient for test-retest reliability and typical error of measurement for the vertical jump test were 0.96 and 3.3%, respectively.

Speed

Rugby league players require the ability to move quickly in order to position themselves in attack and defence.⁴ However, time-motion studies have shown that rugby league players are rarely required to sprint distances greater than 40 m in a single bout of intense activity.⁶ The running speed of players was evaluated with a 10, 20, and 40 m sprint effort⁵ using dual beam electronic timing gates (Swift Performance Equipment). The timing gates were positioned 10, 20, and 40 m cross wind from a pre-determined starting point. Players were instructed to run as quickly as possible along the 40 m distance from a standing start. All tests were conducted on a well grassed surface. Subjects commenced the test in their own time, with timing starting once the beams of the first (0 m) timing gate were broken. Speed was measured to the nearest 0.01 s with the fastest value obtained from two trials used as the speed score. The intraclass correlation coefficient for test-retest reliability and typical error of measurement for the 10, 20, and 40 m sprint tests were 0.95, 0.97, and 0.97, and 1.8%, 1.3%, and 1.2%, respectively.

Agility

Rugby league players require the ability to rapidly accelerate, decelerate, and change direction.⁴ The agility of players was evaluated using an L run¹⁵ using dual beam electronic timing gates (Swift Performance Equipment). The L run requires players to change direction laterally, and based on time-motion studies,¹⁷ has been suggested to reflect the movement patterns of rugby league. Three cones, approximately 1 m in height, were placed 5 m apart in the shape of an “L”. Players ran forward 5 m, turned to their left, ran forward 5 m, turned 180°, and followed the same course to return to the finish line. Agility times were measured to the nearest 0.01 s with the fastest value obtained from two trials used as the agility

score. The intraclass correlation coefficient for test-retest reliability and typical error of measurement for the L run were 0.90 and 2.8%, respectively.

Maximal aerobic power

Depending on the level of competition, rugby league matches last 60–80 min, with players covering 8458–9929 m per match.⁴ Players also require high levels of aerobic fitness to aid recovery after high intensity bouts of activity. Maximal aerobic power was estimated using the multi-stage fitness test.¹⁶ Players were required to run back and forth (shuttle run) along a 20 m track, keeping in time with a series of signals on a compact disk. The frequency of the audible signals (and hence, running speed) was progressively increased, until subjects reached volitional exhaustion. Maximal aerobic power ($\dot{V}O_{2max}$) was estimated using regression equations described by Ramsbottom *et al.*¹⁶ When compared to treadmill determined $\dot{V}O_{2max}$, it has been demonstrated that the multi-stage fitness test provides a valid estimate of maximal aerobic power.¹⁶ In addition, in a previous study,¹¹ rugby league players completed duplicate multi-stage fitness tests, performed 1 week apart, to determine test-retest reliability. The intraclass correlation coefficient for test-retest reliability and typical error of measurement for the multi-stage fitness test were 0.90 and 3.1%, respectively.

Statistical analysis

Data were collected from 115 forwards (37 props, 31 hookers, 36 second-rowers, 11 locks) and 125 backs (27 halfbacks, 11 five-eighths, 27 centres, 39 wingers, 21 fullbacks). The hookers and halves positional group consisted of hookers, halfbacks, and five-eighths. The backrowers positional group consisted of second-rowers and locks, while the outside backs positional group consisted of centres, wingers, and fullbacks. The total number of players in the props, hookers and halves, backrowers, and outside backs positional groups was 37, 69, 47, and 87, respectively. Differences in the anthropometric characteristics, muscular power, speed, agility, and estimated $\dot{V}O_{2max}$ of different playing positions and positional groups were compared using a one way analysis of variance. When required, comparisons of group means were performed using a Scheffe's post hoc test. The level of significance was set at $p < 0.05$ and all data are reported as means and 95% confidence intervals (CI).

RESULTS

Anthropometric characteristics

The mean (95% CI) age and playing experience of all players were 17.2 (95% CI: 17.1 to 17.4) years and 8.7 (95% CI: 8.2 to 9.2) years, respectively. The mean (95% CI) height, body mass, and sum of four skinfolds for all players were 176.1

(95% CI: 175.3 to 176.8) cm, 79.5 (95% CI: 77.7 to 81.4) kg, and 40.4 (95% CI: 38.1 to 42.7) mm, respectively. Significant differences ($p < 0.05$) were detected among individual positions for height, body mass, and skinfold thickness. Props were significantly ($p < 0.05$) taller, heavier, and had a greater skinfold thickness than all other positions. Halfbacks were significantly ($p < 0.05$) shorter than the second row position. When data were analysed according to positional similarities, it was found that the props positional group was taller, heavier, and had a greater skinfold thickness than all other positional groups. The hookers and halves positional group was significantly ($p < 0.05$) shorter and lighter than all other positional groups (tables 1 and 2).

Physiological characteristics

The mean (95% CI) vertical jump height, agility, 10, 20, and 40 m speed, and estimated $\dot{V}O_{2max}$ of all players was 47.5 (95% CI: 46.2 to 48.8) cm, 6.00 (95% CI: 5.93 to 6.07) s, 2.08 (95% CI: 2.05 to 2.11) s, 3.45 (95% CI: 3.42 to 3.49) s, 5.88 (95% CI: 5.82 to 5.93) s, and 46.2 (95% CI: 45.4 to 47.1) ml $kg^{-1} min^{-1}$, respectively. There were no significant differences ($p > 0.05$) among individual positions for 10 and 20 m speed, agility, or vertical jump height. However, the halfback and centre positions were faster than props over 40 m. Halfbacks had significantly ($p < 0.05$) greater estimated $\dot{V}O_{2max}$ than props. When data were analysed according to positional similarities, it was found that the props positional group had significantly lower 20 and 40 m speed and agility than the hookers and halves and outside backs positional groups. The hookers and halves had significantly faster 10 m speed than the outside backs positional group. In addition, hookers and halves and outside backs had a significantly greater estimated $\dot{V}O_{2max}$ than the props positional group (tables 3 and 4).

DISCUSSION

The present study is the first to develop a physiological profile of specific individual playing positions and playing groups in junior rugby league players. The speed, muscular power, and estimated $\dot{V}O_{2max}$ are superior to those reported previously for junior sub-elite rugby league players, but are lower than previously reported for junior elite rugby league players, reflecting, at least in part, the higher playing intensity in elite level competition, or the larger sample size of the present study. In a study of junior rugby league players, Gabbett¹² reported differences in selected physical characteristics between forwards and backs, with backs significantly lighter and demonstrating greater aerobic fitness than forwards. In a subsequent study, Gabbett and Herzig¹³ reported differences in the physiological and anthropometric characteristics of junior rugby league forwards and backs, with backs significantly lighter and demonstrating greater lower body

Table 1 Anthropometric characteristics of specific individual positions in junior rugby league players

	Age (years)	Playing experience (years)	Height (cm)	Body mass (kg)	Sum of skinfolds (mm)
Prop	17.6 (17.2 to 18.0)	6.4 (4.9 to 7.9)‡§	183.9 (182.1 to 185.7)*	101.1 (97.5 to 104.8)*	72.0 (64.8 to 79.2)*
Hooker	17.3 (16.9 to 17.6)	11.7 (10.7 to 12.7)	171.9 (171.1 to 172.7)	69.9 (66.5 to 73.2)†	35.9 (31.3 to 40.5)
Second row	17.2 (16.8 to 17.6)	8.3 (7.4 to 9.3)	176.8 (175.3 to 178.2)	83.6 (80.4 to 86.9)	39.5 (36.1 to 42.9)
Lock	16.5 (16.0 to 17.0)	8.9 (7.4 to 10.3)	176.7 (174.3 to 179.1)	74.8 (70.1 to 79.5)	33.7 (28.9 to 38.5)
Halfback	16.7 (16.4 to 17.0)	10.5 (9.9 to 11.1)	170.6 (168.1 to 173.2)†	69.1 (66.3 to 72.0)†	40.9 (38.1 to 43.8)
Five-eighth	16.7 (16.2 to 17.3)	8.9 (6.5 to 11.3)	176.3 (174.4 to 178.1)	72.0 (65.5 to 78.5)	24.7 (23.7 to 25.8)
Centre	17.0 (16.5 to 17.4)	7.5 (6.8 to 8.3)	176.7 (175.6 to 177.9)	79.6 (76.1 to 83.0)	34.8 (30.9 to 38.7)
Wing	17.7 (17.3 to 18.0)	7.7 (6.1 to 9.2)	176.4 (175.0 to 177.7)	72.9 (70.2 to 75.5)†	30.7 (28.3 to 33.1)
Fullback	17.4 (17.0 to 17.9)	10.9 (9.8 to 12.1)	177.1 (175.5 to 178.7)	78.8 (73.4 to 84.2)	36.2 (32.0 to 40.4)

Data are expressed as means (95% CI). CI, confidence interval.

*Significantly different ($p < 0.05$) from all other positions; †significantly different ($p < 0.05$) from second row; ‡significantly different ($p < 0.05$) from fullback;

§significantly different ($p < 0.05$) from hooker.

Table 2 Anthropometric characteristics of positional groups in junior rugby league players

	Age (years)	Playing experience (years)	Height (cm)	Body mass (kg)	Sum of skinfolds (mm)
Props	17.6 (17.2 to 18.0)	6.4 (4.9 to 7.9)	183.9 (182.1 to 185.7)*	101.1 (97.5 to 104.8)*	72.0 (64.8 to 79.2)*
Hookers and halves	17.0 (16.8 to 17.2)	10.7 (10.0 to 11.4)‡	172.2 (171.0 to 173.4)†	69.9 (67.8 to 72.0)†	34.7 (31.9 to 37.5)
Backrowers	17.0 (16.7 to 17.3)	8.5 (7.7 to 9.3)	176.8 (175.6 to 178.0)	81.5 (78.6 to 84.4)	38.2 (35.4 to 41.1)
Outside backs	17.4 (17.1 to 17.6)	8.7 (7.9 to 9.5)	176.6 (175.9 to 177.4)	76.4 (74.2 to 78.5)	33.0 (31.1 to 34.9)

Data are expressed as means (95% CI). CI, confidence interval.

*†Significantly different ($p < 0.05$) from all other positional groups; ‡significantly different ($p < 0.05$) from props positional group.

muscular power, speed, and estimated $\dot{V}O_{2max}$ than forwards. However, while these studies have provided important information on the physiological and anthropometric characteristics of junior rugby league forwards and backs, measurements have been limited to single sub-elite teams¹² or elite development squads,¹³ making comparisons among specific individual playing positions difficult. Studies from single teams may not be representative of multiple teams as the physiological and anthropometric characteristics may differ according to coaching philosophies, thereby under- or over-estimating the fitness of junior and senior players, relative to a larger sample. The finding of similar physiological and anthropometric characteristics among most individual playing positions in a large sample of players suggests that position specific training does not occur in junior rugby league. These findings are consistent with a recent study of amateur rugby league players that demonstrated no significant differences between forwards and backs as regards training time devoted to the development of muscular power, speed, and aerobic fitness.⁹

An alternative explanation for the finding of similar physiological and anthropometric characteristics among most individual playing positions is that the physiological demands of match play may be similar among individual positions in junior rugby league players. Estell *et al*¹⁸ studied the heart rate responses of junior rugby league players during competition. On average, players performed at or above 90% of their individual maximum heart rate, with 30% of match play spent in high intensity activities (>85% maximum heart rate). Collectively, these findings demonstrate the intense nature of junior rugby league match play. Interestingly, no significant differences were found among playing positions for heart rate responses during competition. While these findings may suggest that the physiological demands of junior rugby league match play are similar among individual positions, the findings of Estell *et al*¹⁸ are dated, and the use of heart rate data alone may not provide an accurate representation of specific passages of intense activity. Furthermore, based on time-motion analysis of elite rugby league match play,⁶ it is reasonable to expect that the physiological demands (movement patterns, distance covered, ratio of high intensity activity to low intensity activity, and number

and intensity of physical collisions) may differ among individual playing positions. Clearly, further studies are required to investigate the physiological demands and work rates of junior rugby league match play.

The present study of junior rugby league players found an average estimated $\dot{V}O_{2max}$ of 46.2 ml kg⁻¹ min⁻¹. Average measurements of 10, 20, and 40 m speed, and vertical jump height were 2.08, 3.45, and 5.88 s and 47.5 cm, respectively. These findings are similar to the 10 m speed (2.13 s), 20 m speed (3.40 s), 40 m speed (5.97 s), vertical jump (46.9 cm), and estimated $\dot{V}O_{2max}$ (45.5 ml kg⁻¹ min⁻¹) scores of senior sub-elite rugby league players (unpublished observations), and contrast significantly with the 24.0–40.3% difference in muscular power, speed, and estimated $\dot{V}O_{2max}$ between junior and senior rugby league players reported previously.¹² The higher physiological capacities of the junior rugby league players of the present study could be due to lower injury rates,^{19–21} or match loads²² at lower playing levels. Indeed, recent evidence has demonstrated that the fitness of senior rugby league players declines throughout a competitive season as a result of high match loads, increases in injury rates, and residual fatigue associated with limited recovery time between successive matches.¹¹ Conversely, the fitness of junior rugby league players is maintained over the entire season.²¹ Furthermore, a recent study of junior and senior rugby league players reported greater improvements in maximal aerobic power and muscular power in response to the same field conditioning program, suggesting that junior players demonstrate greater physiological adaptations to a given training stimulus than senior players.²⁰

Consistent with previous studies of senior rugby league players,^{4,5} the present study found that props were taller, heavier, and had greater skinfold thickness than other individual positions and positional groups. These results are also in partial agreement with previous studies that have found that body mass successfully predicts selection as a forward or back.^{10,12} Props spend a large proportion of match play involved in tackling and physical collisions. As a result, the higher body mass of props may assist in the development of greater momentum and impact forces associated with these activities. The higher body mass would also reduce the likelihood of opposing players effecting tackles on these

Table 3 Physiological characteristics of specific individual positions in junior rugby league players

	10 m (s)	20 m (s)	40 m (s)	Agility (s)	Vertical jump (cm)	$\dot{V}O_{2max}$ (ml kg ⁻¹ min ⁻¹)
Prop	2.14 (2.07 to 2.20)	3.62 (3.55 to 3.69)	6.18 (6.04 to 6.32)	6.37 (6.21 to 6.52)	44.0 (41.6 to 46.4)	42.2 (39.8 to 44.7)
Hooker	2.04 (1.96 to 2.12)	3.38 (3.27 to 3.48)	5.89 (5.75 to 6.03)	5.86 (5.61 to 6.11)	47.9 (43.7 to 52.0)	46.9 (44.3 to 49.5)
Second row	2.07 (1.98 to 2.16)	3.47 (3.36 to 3.57)	5.89 (5.73 to 6.06)	6.10 (5.91 to 6.30)	49.0 (45.5 to 52.6)	45.1 (42.8 to 47.3)
Lock	2.07 (1.95 to 2.19)	3.49 (3.34 to 3.63)	5.93 (5.69 to 6.18)	5.64 (5.35 to 5.94)	45.2 (38.6 to 51.8)	44.6 (40.6 to 48.6)
Halfback	1.95 (1.86 to 2.03)	3.52 (3.48 to 3.56)	5.62 (5.47 to 5.77)*	6.01 (5.79 to 6.24)	50.4 (45.8 to 55.0)	50.5 (48.4 to 52.6)*
Five-eighth	1.93 (1.82 to 2.03)	3.27 (3.13 to 3.41)	5.71 (5.61 to 5.82)	5.71 (5.34 to 6.08)	48.5 (43.0 to 54.0)	48.3 (44.1 to 52.4)
Centre	2.02 (1.93 to 2.11)	3.34 (3.25 to 3.43)	5.71 (5.58 to 5.84)*	5.89 (5.68 to 6.09)	50.4 (46.9 to 53.9)	47.1 (44.5 to 49.8)
Wing	2.18 (2.10 to 2.27)	3.49 (3.40 to 3.58)	5.94 (5.81 to 6.07)	5.98 (5.85 to 6.12)	45.4 (42.6 to 48.2)	45.7 (43.7 to 47.7)
Fullback	2.16 (2.10 to 2.22)	3.39 (3.29 to 3.49)	5.84 (5.74 to 5.93)	5.90 (5.72 to 6.08)	42.8 (38.2 to 47.3)	47.8 (45.4 to 50.1)

Data are expressed as means (95% CI). CI, confidence interval. $\dot{V}O_{2max}$, estimated maximal aerobic power.

*Significantly different ($p < 0.05$) from prop.

Table 4 Physiological characteristics of positional groups in junior rugby league players

	10 m (s)	20 m (s)	40 m (s)	Agility (s)	Vertical jump (cm)	$\dot{V}O_{2max}$ (ml kg ⁻¹ min ⁻¹)
Prop	2.14 (2.07 to 2.20)	3.62 (3.55 to 3.69)	6.18 (6.04 to 6.32)	6.37 (6.21 to 6.52)	44.0 (41.6 to 46.4)	42.2 (39.8 to 44.7)
Hookers and halves	1.99 (1.94 to 2.04)	3.40 (3.33 to 3.46)*	5.76 (5.67 to 5.85)*	5.88 (5.72 to 6.04)*	49.0 (46.2 to 51.7)	48.4 (46.8 to 50.0)*
Backrowers	2.07 (2.00 to 2.15)	3.47 (3.38 to 3.56)	5.90 (5.76 to 6.04)	6.02 (5.84 to 6.19)	48.2 (45.1 to 51.3)	45.0 (43.0 to 46.9)
Outside backs	2.12 (2.07 to 2.17)†	3.42 (3.36 to 3.47)*	5.84 (5.76 to 5.91)*	5.93 (5.83 to 6.03)*	47.1 (45.1 to 49.1)	46.6 (45.3 to 47.9)

Data are expressed as means (95% CI). CI, confidence interval. $\dot{V}O_{2max}$, estimated maximal aerobic power.

*Significantly different ($p < 0.05$) from props positional group; †significantly different ($p < 0.05$) from hookers and halves positional group.

players.⁵ However, while an increased skinfold thickness has been suggested to provide a protective role against the high numbers of physical collisions sustained by props,²³ the higher body fat component of props may also increase the physiological demands on players required to support this weight during a match, and diminish the ability to dissipate heat during intense physical activity.⁵

The hookers and halves and outside backs positional groups were faster over 40 m than the props positional group. These findings may be expected given that props are rarely required to run further than 10 m in a single bout of intense activity.⁶ However, an interesting finding of this study is the lower 10 m speed of the outside backs positional group relative to the hookers and halves positional group, with the wing position demonstrating the slowest 10 m speed of all of the outside backs. Results from elite rugby league studies have shown that wingers are traditionally the fastest players on the rugby league team and use their speed to either chase attacking players or to attack while running with the ball.⁴ Indeed, time-motion studies of elite rugby league players have shown that the ratio of low intensity activity to high intensity activity, and time spent in sprinting activities are significantly greater in wingers than props,⁶ with wingers having faster 15 m speed than props, and faster 40 m speed than props, second-rowers, locks, halfbacks, and five-eighths.⁴ The finding of faster 10 m speed in the hookers and halves positional group suggests that the hooker, halfback, and five-eighth positions rely predominantly on acceleration speed while maximum speed is a more important quality for the outside backs positional group. Alternatively, the finding from this study that outside backs (particularly wingers) had slower 10 m speed than other playing positions may reflect a tactical decision by coaches, with faster players selected into other key positional roles, such as halfback, five-eighth, or hooker.

The halfback position and the hookers and halves positional group had a greater estimated $\dot{V}O_{2max}$ than the props positional group. These findings are in agreement with studies of elite rugby league players that found significantly greater estimated $\dot{V}O_{2max}$ in hookers (55.2 ml kg⁻¹ min⁻¹) and halves (52.0 ml kg⁻¹ min⁻¹) than props (48.6 ml kg⁻¹ min⁻¹).⁵ Furthermore, the finding of lower aerobic fitness in props is in agreement with Meir *et al*⁴ who found greater 5 min running distance in hookers and halfbacks (1353 m) than props and second-rowers (1264 m). The higher estimated $\dot{V}O_{2max}$ in hookers and halves may reflect their high work rate throughout a match, with time-motion studies revealing that hookers cover a greater total distance during the course of a match than any other position.⁶ The low aerobic fitness of props is of particular concern given their greater involvement in tackles and physical collisions,⁷ and the higher intensity of match play in this position.⁶ In addition, it has been reported that player fatigue²⁴ and a low estimated $\dot{V}O_{2max}$ ²⁵ are risk factors for injuries in rugby league players, with props demonstrating the greatest susceptibility to fatigue related injuries.²⁶ Clearly, junior rugby league props could benefit from additional aerobic training to enhance

performance and reduce the incidence of injury associated with this position. The obvious challenge for conditioning coaches is to enhance the aerobic fitness of props without compromising the muscular strength of these players.

The high intensity and speed of rugby league, combined with the requirement for rapid acceleration, deceleration, and changes of direction in hookers and halves, may explain the superior speed and agility in these players. As the hookers and halves positional group defend in different field positions (hooker in the centre of the ruck, five-eighth at the edge of the ruck, and halfback in the second line of defence), the superior physiological capacities are unlikely to be related to defensive efforts. However, all three positions play a similar ball distribution and supporting role in attack. In addition, the hookers and halves positional group is often required to play a "probing" role in attack, by taking the football to the defensive line, and reacting to and evading defending players. Clearly, the hookers and halves positional group would benefit from specific speed and agility training to improve their ability to effect rapid changes in direction. An agility training program designed to enhance components of change of direction speed (for example, sprinting speed, sprinting technique, strength, power, and reactive strength) and perceptual and decision making (for example, visual scanning, anticipation, pattern recognition, and situation knowledge)²⁷ could form the basis of a speed and agility program for hookers and halves.

The finding of similar vertical jump scores among individual positions and positional playing groups is in agreement with previous studies that reported similar lower body muscular power among elite rugby league props, backrowers, outside backs, and hookers and halves.⁵ The ability to rapidly generate high levels of muscular force is an important attribute of rugby league players. Players are required to have high levels of muscular power in order to effectively perform the tackling, lifting, pushing, and pulling tasks that occur during a match.⁴ In addition, high levels of muscular power contribute to running speed, and are required to provide fast play-the-ball speed and leg drive in tackles.¹ The finding of similar vertical jump scores among positions suggests that lower body muscular power is an equally important characteristic for all playing positions. Intuitively, one might expect a greater lower body muscular power in props given their requirement to work over short (approximately 10 m) distances and their greater involvement in the tackling and lifting tasks that occur during a match. It is possible that the similar vertical jump results between props and other playing positions reflect the higher skinfold thickness of props and an attenuation of the power to body mass ratio in these players.⁹ Alternatively, the similarities in vertical jump height among playing positions may reflect the relative insensitivity of the vertical jump test to detect positional differences in lower body muscular power.

In conclusion, the present study compared the physiological and anthropometric characteristics of specific playing positions and positional playing groups in junior rugby

What is already known on this topic

Physical performance profiles of junior rugby league players are limited.

What this study adds

These findings provide normative data and realistic performance standards for junior rugby league players competing in specific individual positions and positional playing groups.

league players. The results of this study demonstrate that few physiological and anthropometric differences exist among individual playing positions in junior rugby league players, although props are taller, heavier, have greater skinfold thickness, lower 20 and 40 m speed, agility, and estimated maximal aerobic power than other positional playing groups. Furthermore, these findings provide normative data and realistic performance standards for junior rugby league players competing in specific individual positions and positional playing groups.

Competing interests: none declared

REFERENCES

- Gabbett TJ. Science of rugby league football: a review. *J Sports Sci* 2005 (in press).
- Baker D. Differences in strength and power among junior-high, senior-high, college-aged, and elite professional rugby league players. *J Strength Cond Res* 2002;**16**:581–5.
- Baker D. Comparison of upper-body strength and power between professional and college-aged rugby league players. *J Strength Cond Res* 2001;**15**:30–5.
- Meir R, Newton R, Curtis E, et al. Physical fitness qualities of professional rugby league football players: determination of positional differences. *J Strength Cond Res* 2001;**15**:450–8.
- O'Connor D. Physiological characteristics of professional rugby league players. *Strength Cond Coach* 1996;**4**:21–6.
- Meir R, Colla P, Milligan C. Impact of the 10-meter rule change on professional rugby league: implications for training. *Strength Cond* 2001;**23**:42–6.
- Gissane C, White J, Kerr K, et al. Physical collisions in professional super league. The demands of different player positions. *Cleve Med J* 2001;**4**:137–46.
- Clark L. A comparison of the speed characteristics of elite rugby league players by grade and position. *Strength Cond Coach* 2002;**10**:2–12.
- Gabbett TJ. Physiological and anthropometric characteristics of amateur rugby league players. *Br J Sports Med* 2000;**34**:303–7.
- Gabbett TJ. Influence of physiological characteristics on selection in a semi-professional rugby league team: a case study. *J Sports Sci* 2002;**20**:399–405.
- Gabbett TJ. Changes in physiological and anthropometric characteristics of rugby league players during a competitive season. *J Strength Cond Res* 2005;**19**:400–8.
- Gabbett TJ. Physiological characteristics of junior and senior rugby league players. *Br J Sports Med* 2002;**36**:334–9.
- Gabbett TJ, Herzig PJ. Physiological characteristics of junior elite and sub-elite rugby league players. *Strength Cond Coach* 2004;**12**:19–24.
- Norton K, Marfell-Jones M, Whittingham N, et al. Anthropometric assessment protocols. In: Gore CJ, ed. *Physiological tests for elite athletes*. Champaign, IL: Human Kinetics, 2000:66–85.
- Webb P, Lander J. An economical fitness testing battery for high school and college rugby teams. *Sports Coach* 1983;**7**:44–6.
- Ramsbottom R, Brewer J, Williams C. A progressive shuttle run test to estimate maximal oxygen uptake. *Br J Sports Med* 1988;**22**:141–4.
- Meir R, Arthur D, Forrest M. Time and motion analysis of professional rugby league: a case study. *Strength Cond Coach* 1993;**1**:24–9.
- Estell J, Lord P, Barnsley L, et al. The physiological demands of rugby league [abstract]. In: *Proceedings of the Australian Conference of Science and Medicine in Sport*, 28–31 October 1996. Canberra: Sports Medicine Australia, 1996:388–9.
- Estell J, Shenstone B, Barnsley L. Frequency of injuries in different age-groups in an elite rugby league club. *Aust J Sci Med Sport* 1995;**27**:95–7.
- Gabbett TJ. Performance changes following a field conditioning program in junior and senior rugby league players. *J Strength Cond Res* 2005 (in press).
- Gabbett TJ. Physiological and anthropometric characteristics of junior rugby league players over a competitive season. *J Strength Cond Res* 2005 (in press).
- Gabbett TJ. Influence of training and match intensity on injuries in rugby league. *J Sports Sci* 2004;**22**:409–17.
- Meir R. Seasonal changes in estimates of body composition in professional rugby league players. *Sport Health* 1993;**11**:27–31.
- Gabbett TJ. Incidence, site, and nature of injuries in amateur rugby league over three consecutive seasons. *Br J Sports Med* 2000;**34**:98–103.
- Gabbett TJ, Domrow N. Risk factors for injury in sub-elite rugby league players. *Am J Sports Med* 2005;**33**:428–34.
- Gabbett TJ. Influence of playing position on the site, nature, and cause of rugby league injuries. *J Strength Cond Res* 2005 (in press).
- Young WB, James R, Montgomery I. Is muscle power related to running speed with changes of direction? *J Sports Med Phys Fitness* 2002;**42**:282–8.